Alberta Air Emissions Trends and Projections

Alberta
Environment

June 18, 2008

Disclaimer:

The information contained in this report was compiled using various sources of data on air emissions for Alberta. Each data source was prepared for a specific purpose and made specific assumptions. It is in that context that the information will have to be examined if an in depth analysis of air emissions data is required.

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1.0 Introduction

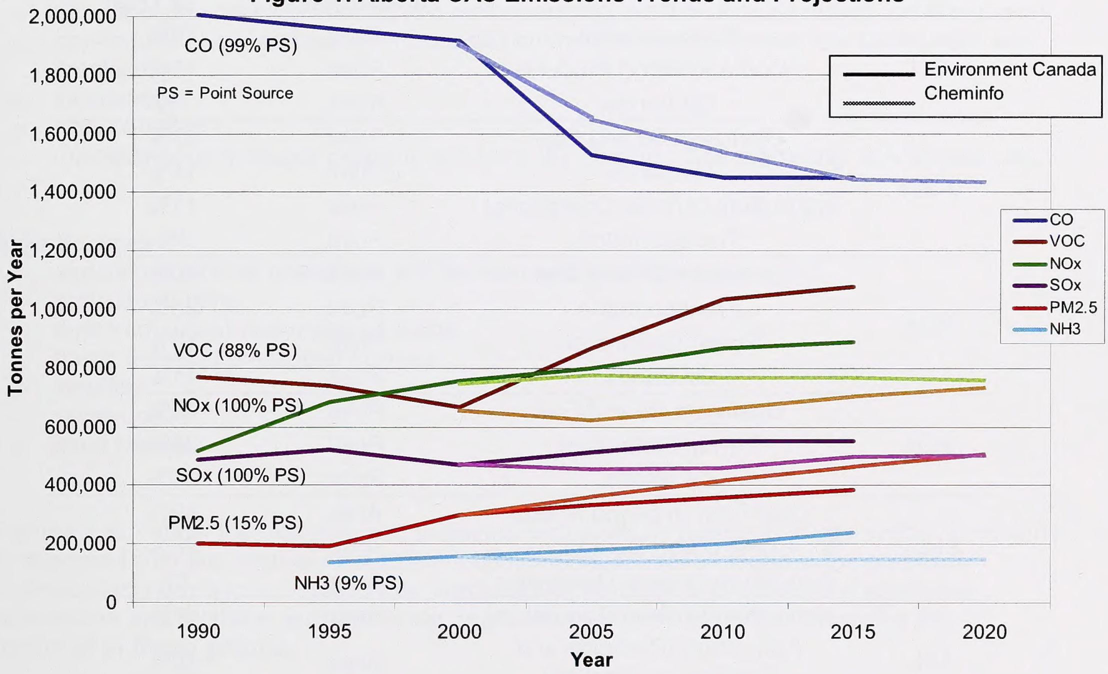
This paper was prepared for the CASA Clean Air Strategy Project Team to provide a summary of air emissions trends and projections for Alberta. Emissions by industry sector and predicted regional distribution of emissions are also presented. In addition emissions information relevant to CASA project teams has been included. Data and figures from various external sources were used and are identified throughout the report.

2.0 Criteria Air Contaminants (CACs)[1,2]

2.1 Total Criteria Air Contaminant Emissions Trends and Projections

The historical and projected emissions in Alberta for criteria air contaminants (sulphur oxides (SO_x), oxides of nitrogen (NO_x), volatile organic compounds (VOCs), carbon monoxide (CO), particulate matter less than 2.5 micrometers in diameter ($PM_{2.5}$), ammonia (NH_3)) are presented in Figure 1. Two data sources were used: Environment Canada[1] data (1990-2015) and Cheminfo[2] data (2000-2020). There are discrepancies between the predicted emissions between the two data sources, especially for VOCs and NOx. Since the Cheminfo data was compiled using bottom-up modified Environment Canada data, it may provide more accurate predictions. Statistical significance of trends was not determined.

Figure 1. Alberta CAC Emissions Trends and Projections



PS: Point Source

The above graph shows a decrease in CO emissions, and after a period of decrease or leveling off, increasing emissions of VOCs, NOx, SOx , $PM_{2.5}$ and NH_3.

[1] Most recent Criteria Air Contaminants Provincial Summary Excel file (AB_Emissions_1990_2015_en) from June 7, 2007

[2] Forecast of Criteria Air Contaminants in Alberta (2002 to 2020), Cheminfo, May 2007

The relative contributions of point and area sources are presented in Table 1. The information was compiled from the 2005 data from Environment Canada.
Only 9% of ammonia emissions are from point sources. Fertilizer and pesticide application as well as agricultural animal operations were considered to be area sources. The majority of $PM_{2.5}$ emissions were also from area sources: mainly unpaved roads and construction operations. Agricultural animal operations account for most of the 12% area source emissions of VOCs. Table 1 presents a summary of the main contributors of area and point source emissions by pollutant.

Table 1. Main Contributors of Emissions by Pollutant (EC 2005 Data)[1]

Pollutant	Contributor	Point Source / Area Source	% Contribution of Total
CO	Transportation	Point	70%
	Wood and Wood Products	Point	15%
	Oil Sands	Point	7%
VOCs	Upstream Oil and Gas	Point	57%
	Oil Sands	Point	14%
	Agriculture (Animal Operations)	Area	11%
	Transportation	Point	9%
NOx	Upstream Oil and Gas	Point	40%
	Transportation	Point	26%
	Power Generation	Point	13%
	Oil Sands	Point	11%
SOx	Upstream Oil and Gas	Point	46%
	Power Generation	Point	25%
	Oil Sands	Point	23%
$PM_{2.5}$	Dust from Unpaved Roads	Area	49%
	Construction Operations	Area	26%
	Agriculture (Animal Operations)	Area	3%
NH_3	Agriculture (Animal Operations)	Area	51%
	Agriculture (Pesticide and Fertilizer Application)	Area	40%
	Chemical and Petrochemical	Point	5%

[1] Environment Canada Criteria Air Contaminants Provincial Summary, June 2007

2.2 Criteria Air Contaminant Emissions by Sector[1]

The sectors and categories used in the following analysis of CACs were:

Point Sources

- electric power generation (utilities)
- oil sands
- upstream oil and gas
- chemical and petrochemical
- petroleum refining
- coal mining
- cement and concrete
- wood and wood products
- other industry (includes mining and rock quarrying, plastics manufacturing, smelting, etc.)
- non-industrial fuel combustion (includes commercial and residential fuel combustion and fireplaces)
- incineration
- transportation
- miscellaneous (includes cigarette smoking, dry cleaning, fuel marketing, solvent use, etc.)

Area Sources

- agriculture (animal operations and fertilizer and pesticide application)
- agricultural tilling
- dust from paved and unpaved roads
- forest fires and prescribed burning
- landfills
- construction
- mine tailings

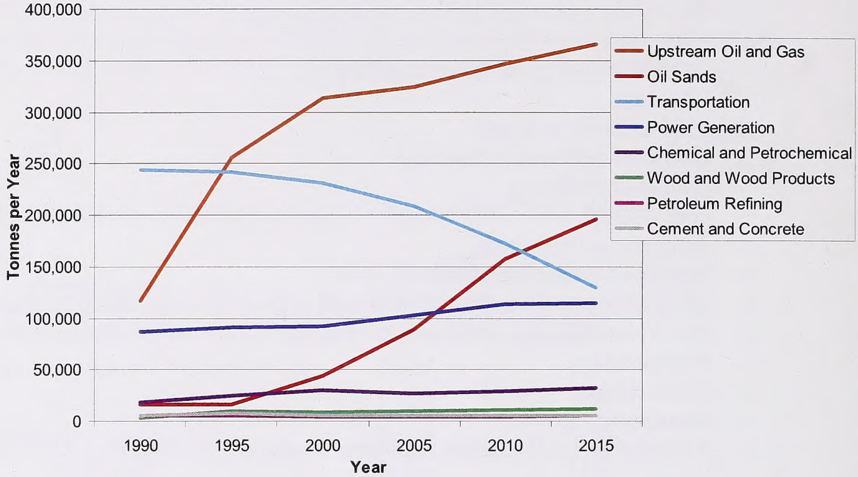
Figures 2 to 7 show the historical and projected emissions by pollutant and by sector. Emissions from sectors that are relatively insignificant contributors are not included in the graphs to improve clarity and focus. Please Note: **Agricultural sources are included (i.e. animal operations and fertilizer and pesticide application) but no other area sources are included in these graphs.**

[1] Most recent Criteria Air Contaminants Provincial Summary Excel file (AB_Emissions_1990_2015_en) from June 7, 2007

Oxides of Nitrogen (NO_X)

NOx emissions are increasing in the upstream oil and gas and oil sands sectors due to increasing development. Emissions are decreasing in the transportation sector due to improving vehicle pollution control technologies.

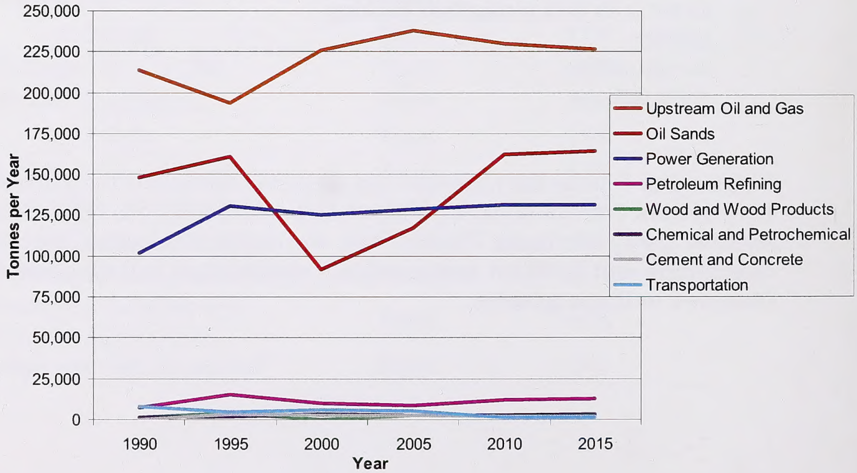
Figure 2. Alberta NOx Emissions



Sulphur Oxides (SO_X)

SOx emissions decreased in the oil sands sector from 2000 to 2005 due to sulphur capture technology implementation but are expected to increase due to increasing development. Upstream oil and gas SOx emissions are decreasing due to flaring reduction and dwindling production.

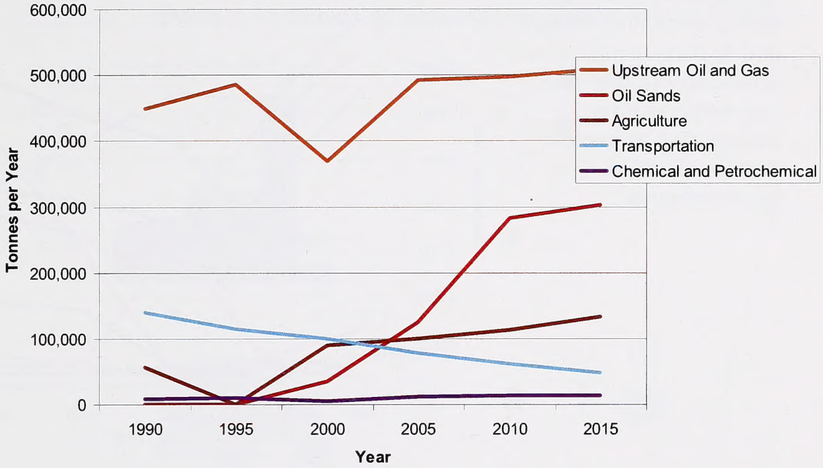
Figure 3. Alberta SOx Emissions



Volatile Organic Compounds (VOC)

VOC emissions are increasing in the oil sands sector due to increasing development. Emissions are decreasing in the transportation sector due to improving vehicle pollution control technologies.

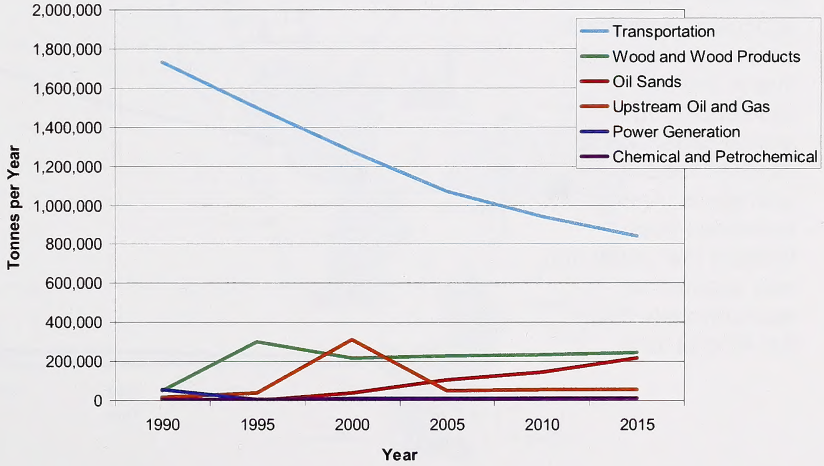
Figure 4. Alberta VOC Emissions



Carbon Monoxide (CO)

Carbon monoxide emissions are overall decreasing due to transportation sector due to vehicle improvements.

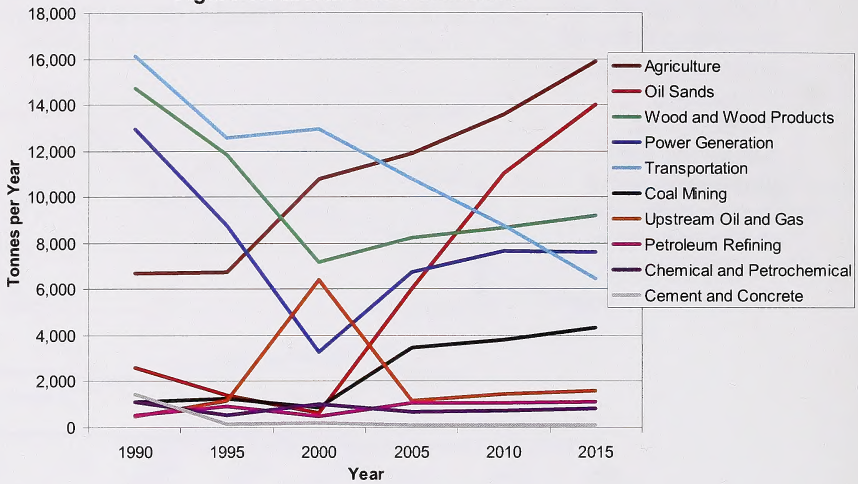
Figure 5. Alberta Carbon Monoxide Emissions



Particulate Matter Less Than 2.5μm in Diameter ($PM_{2.5}$)

$PM_{2.5}$ emissions are increasing in the agriculture, oil sands and coal mining sectors due to increasing development and are decreasing in the transportation sector due to vehicle improvements.

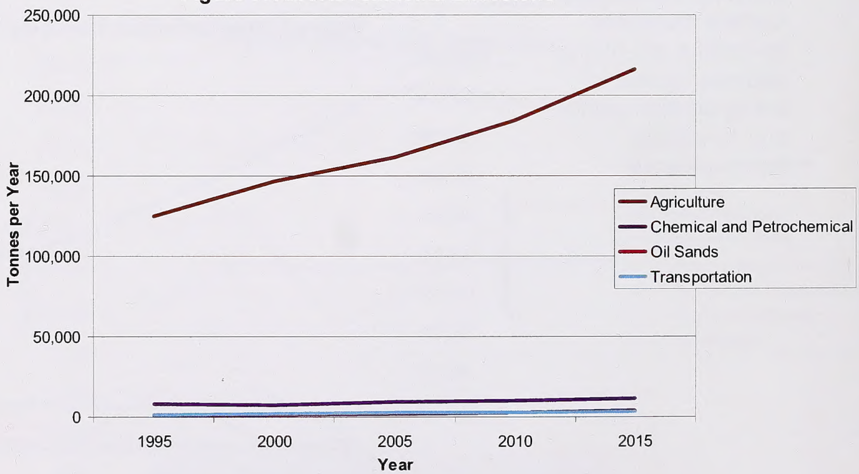
Figure 6. Alberta PM2.5 Emissions



Ammonia (NH_3)

Ammonia emissions and principally attributed to the agriculture sector with emissions increasing due to increasing development and animal capacities at confined feeding operations. Ammonia emissions from fertilizer manufacturing only account for approximately 5% of the Alberta total.

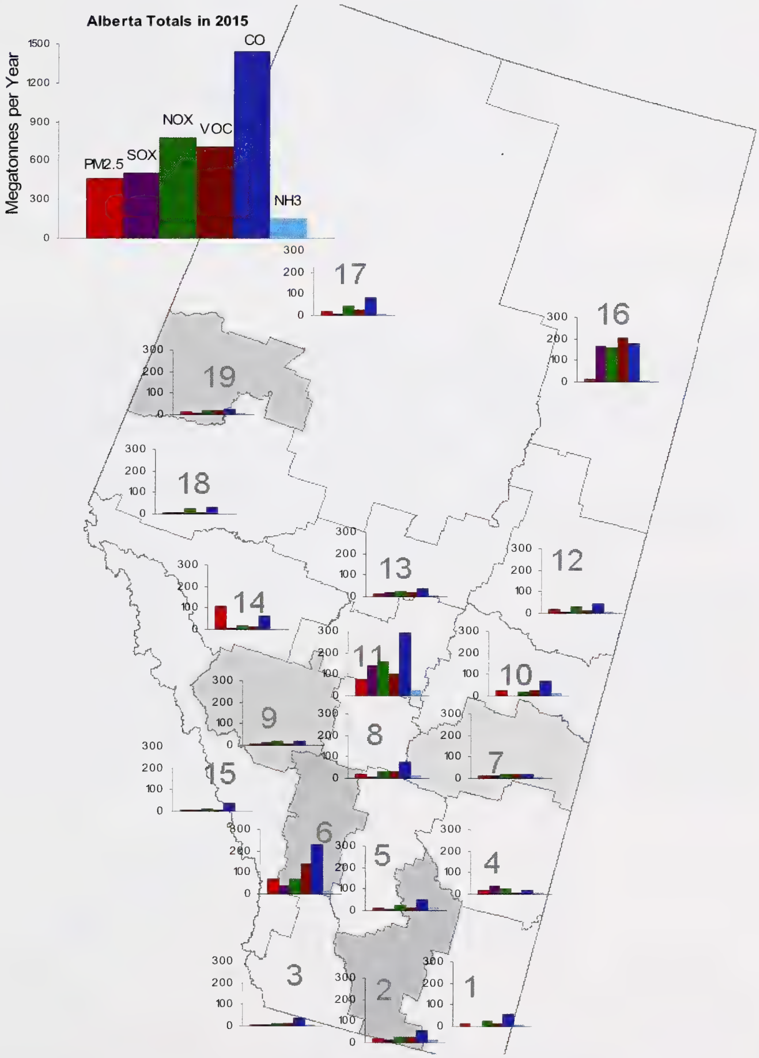
Figure 7. Alberta Ammonia Emissions



2.3 Predicted Regional Distribution of Criteria Air Contaminants[2]

Figure 8 shows the predicted CAC emissions by Census Division in 2015. It is evident that the highest emissions are predicted to be in the Edmonton, Calgary and Fort McMurray areas.

Figure 8. Predicted CAC Emissions by Census Division in 2015



[2] Forecast of Criteria Air Contaminants in Alberta (2002 to 2020), Cheminfo, May 2007

2.4 Regional Distribution of Criteria Air Contaminants by Sector

The majority of emissions due to oil sands operations are in the northeast quadrant of Alberta. Upstream Oil and Gas emissions are mainly in the areas of greatest development from northwestern Alberta to southeastern Alberta. Agricultural emissions are found throughout the arable regions of Alberta but mostly in the central and southern half of the province. Transportation emissions are mainly found in urban areas and the Edmonton-Calgary corridor. Emissions from the chemical and petrochemical sector are found mainly in the Industrial Heartland area east of Edmonton. Power generation and coal mining emissions are mainly from the Lake Wabamun area west of Edmonton. Emissions from wood and wood products facilities are generated throughout the province but a regional concentration is found in northwestern Alberta.

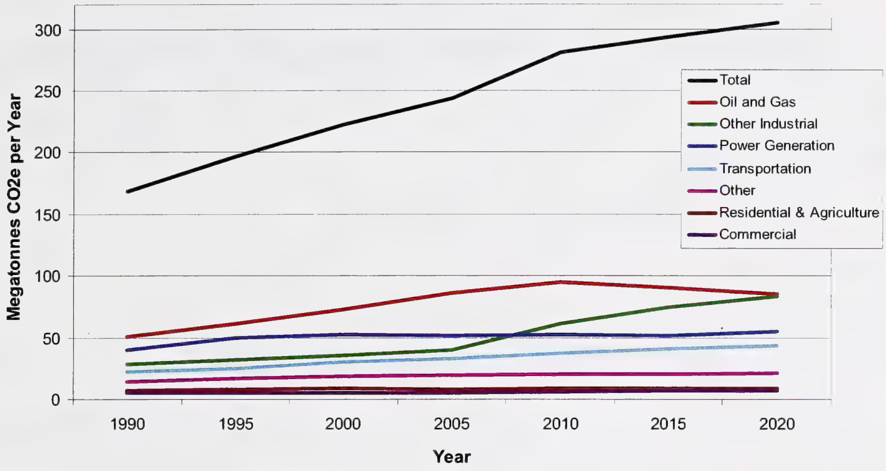
3.0 Greenhouse Gases (GHGs)

Greenhouse gas emissions in Alberta have been increasing and are predicted to keep increasing, as shown in Figure 9. This is mainly due to Alberta's growing economy, energy exports and fossil fuel energy intensive industrial activities. It should be noted that the projections provided in Figure 9 are based on a top-down macroeconomic model to predict emissions[3]. This entails predicting emissions rates as a function of economic indicators such as GDP, population, predicted commodity prices and energy consumption, employment, etc. These projections do not consider the impacts of recently developed policies or regulations, such as Alberta's Specified Gas Emitters Regulation.

The categorizations of the industry sectors in Figure 9 are not necessarily representative of how Alberta categorizes industry. For example, "Oil and Gas" includes *in situ* oil production and conventional oil and gas production whereas "Other Industrial" includes oil sands production, upgrading and refining. GHG emissions from the oil and gas sector are predicted to decrease due to decreasing conventional oil and gas production. Emissions from the "other industrial" sector are predicted to increase, mainly due to increased oil sands production, upgrading and refining. The "other" category includes emissions from agroecosystems, waste and solvent use.

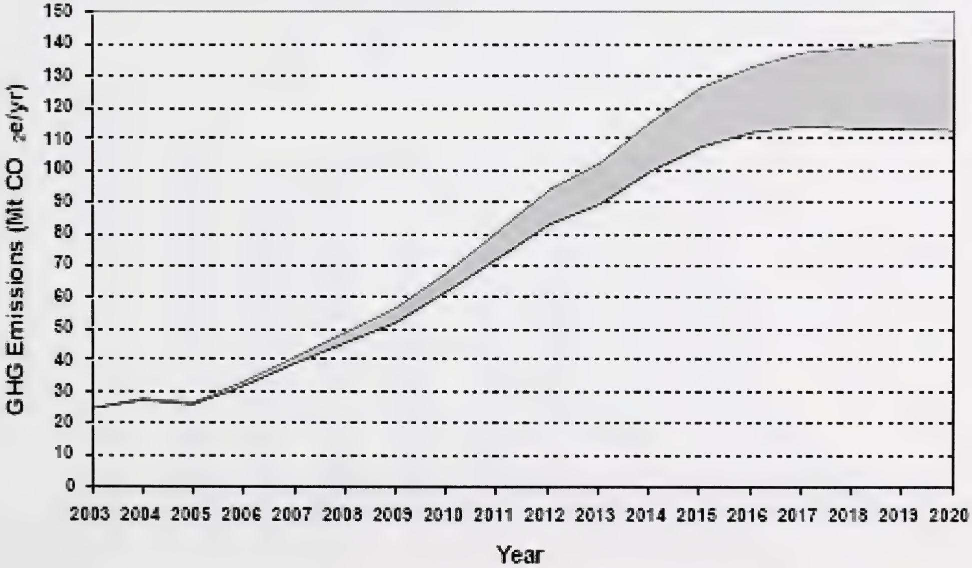
[3] Canada's Energy Outlook: The Reference Case 2006, Natural Resources Canada, 2006

Figure 9. Alberta GHG Emissions Trends and Projections



Predicted emissions from the oil sands sector, likely the greatest source of increasing GHG emissions in Alberta, is provided in Figure 10[4]. In 2005, Alberta's total GHG emissions were 233 megatonnes CO_2e, of which 168 megatonnes were attributed to industry[5]. Figure 10 shows that the contribution from oil sands is predicted to significantly increase from ~25 megatonnes in 2005 to ~125 megatonnes in 2020.

Figure 10. Projected GHG Emissions from Oil Sands (Showing Range Between Low and High Projections)[4]



[4] Carbon Neutral 2020: A Leadership Opportunity in Canada's Oil Sands, The Pembina Institute, October 2006
[5] National Inventory Report, 1990-2005 - Greenhouse Gas Sources and Sinks in Canada, Environment Canada, May 2007

4.0 Other Air Emissions Trends and Projections

The following sections include air emissions trends and projections information from various sources. The objective is to provide more detailed emissions information and context on current issues in Alberta as well as expected emissions reductions from policy decisions and technology improvements.

4.1 CASA Flaring and Venting Project Team

In June 2002, the CASA Flaring and Venting Project Team made 39 recommendations to the CASA Board to reduce gas flaring and venting in Alberta[6]. This work was a continuation of previous efforts at CASA to reduce flaring, principally the recommendations from June 1998 which were implemented by the EUB in Guide 60 (now Directive 060)[7].

The following Tables and Figures demonstrate that since the CASA recommendations and targets were implemented in 1999, solution gas flaring and venting has been reduced substantially.

Table 2. Solution Gas Venting Reduction[8]
(Compared to 2000 Baseline)

Year	Reduction (%)
2001	15
2002	29
2003	38
2004	49
2005	59
2006	56

Table 3. Solution Gas Flaring Reduction[9]
(Based on the 1996 Revised Baseline 1340 10^6 m^3/yr

Year	Firm Target Reduction (%)	Actual Reduction (%)
1999	None Established	30
2000	15	38
2001	25	50
2002	50	62
2003	None Established	70

[6] CASA: Gas Flaring and Venting in Alberta, June 2002
[7] EUB: Directive 060: Upstream Petroleum Industry Flaring, Incinerating, and Venting, November 2006
[8] EUB: Upstream Petroleum Industry Flaring and Venting Report, June 2007
[9] CASA: Gas Flaring and Venting in Alberta, September 2004

Figure 11. Solution Gas Conserved, Flared and Vented[8]

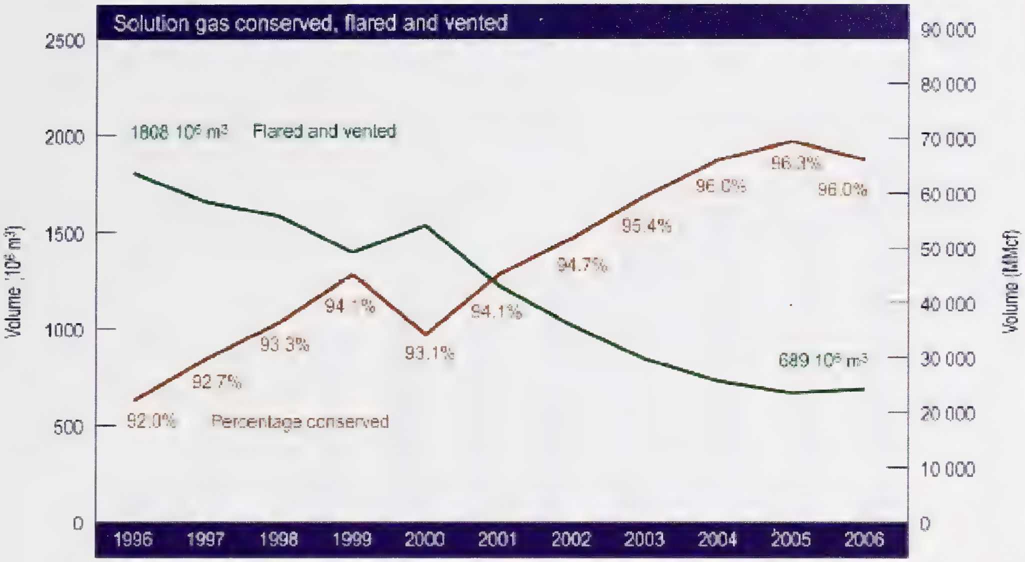
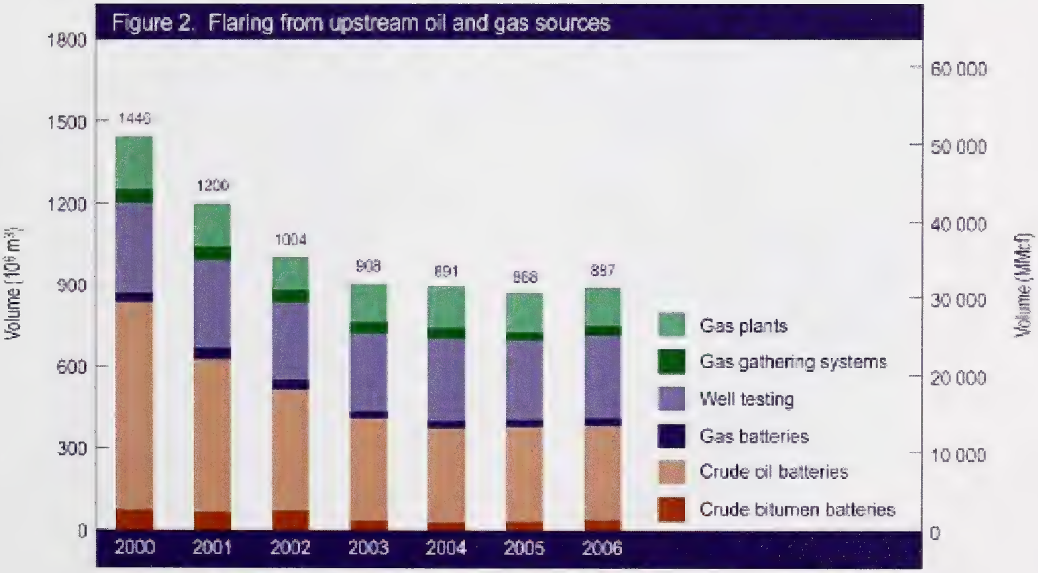
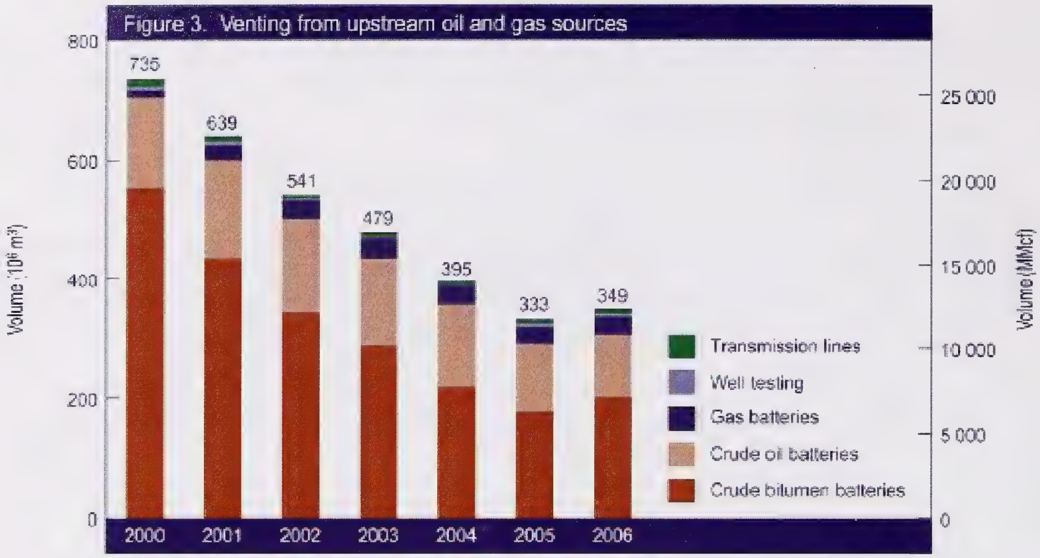


Figure 12. Flaring from Upstream Oil and Gas Sources[8]



[8] EUB: Upstream Petroleum Industry Flaring and Venting Report, June 2007

Figure 13. Venting from Upstream Oil and Gas Sources[8]



Figures 14 and 15 illustrate solution gas flaring and venting quantities by township for 2003.

Figure 14. 2003 Solution Gas Flaring[9]

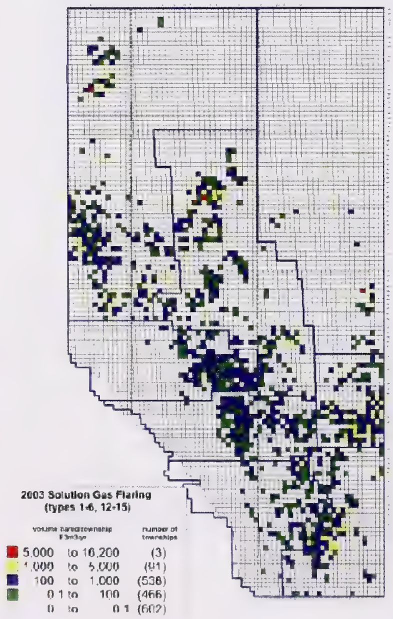
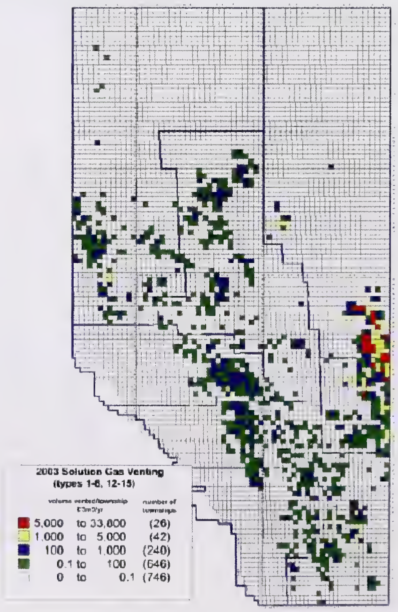


Figure 15. 2003 Solution Gas Venting[9]

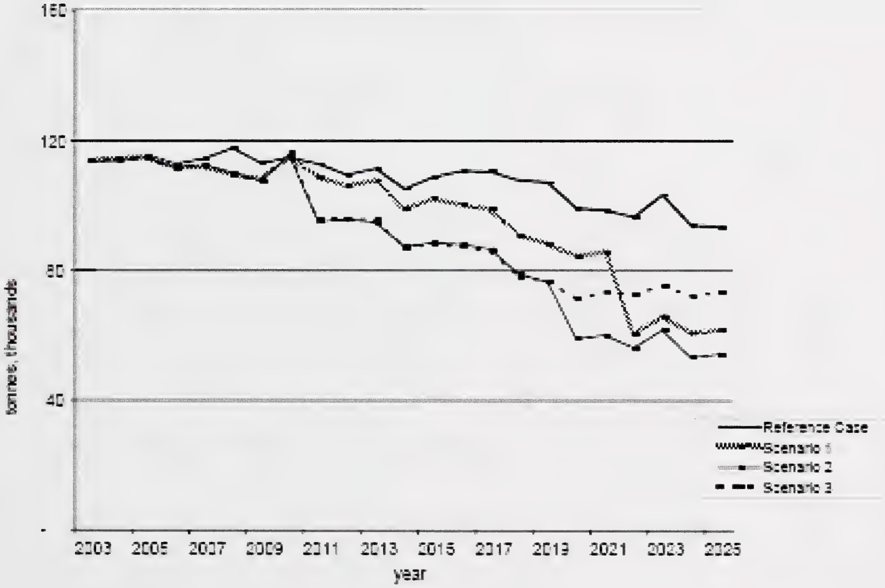


[8] EUB: Upstream Petroleum Industry Flaring and Venting Report, June 2007
[9] CASA: Gas Flaring and Venting in Alberta, September 2004

4.2 CASA Electricity Project Team

In order to assess the predicted impact of implementing a recommended emissions reduction framework for the electricity sector in Alberta, the CASA Electricity Project Team retained a consultant to model predicted emissions for different scenarios[10].The Reference Case represents "business-as-usual" without any recommendations or policies being implemented whereas the different scenarios are based on implementation of different emissions reduction policies. From the Project Team Report: "Scenario 1 was a baseline and credit system for NO_x and SO_2 that required units to reduce to BATEA (Best available technology economically achievable) levels at the end of Design Life. Scenarios 2 and 3 were cap and trade systems for NOx and SO2 where the caps were reduced every five years, with scenario 2 being the more stringent of the two. The same set of requirements was used for mercury; greenhouse gases, and primary PM emissions, and for renewables in all three scenarios." It can be seen from Figures 16 to 18 that implementation of any policy was predicted to decrease emissions of SO_2, NO_x and GHGs compared to the Reference Case.

Figure 16. Modeled SO_2 Emissions Changes[10]



[10] CASA: An Emissions Management Framework for the Alberta Electricity Sector Report to Stakeholders, November 2003

Figure 17. Modeled NO_X Emissions Changes[10]

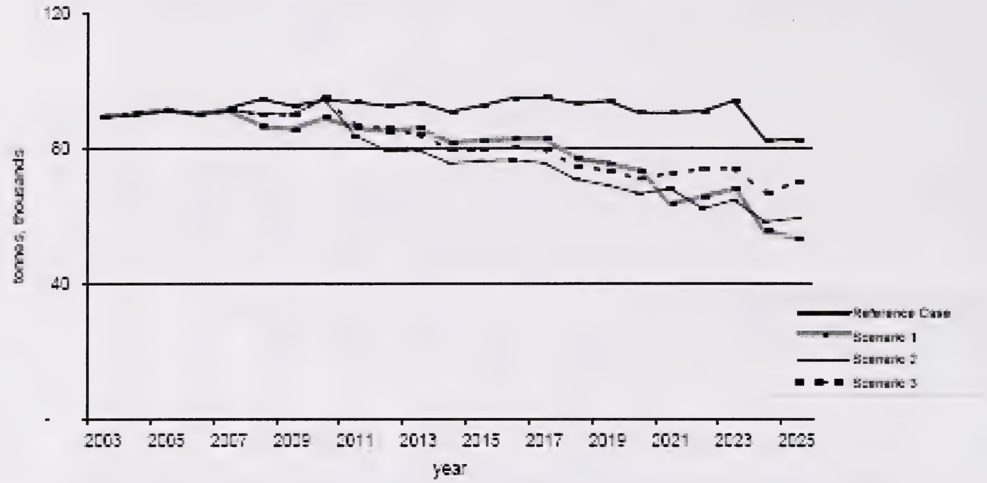
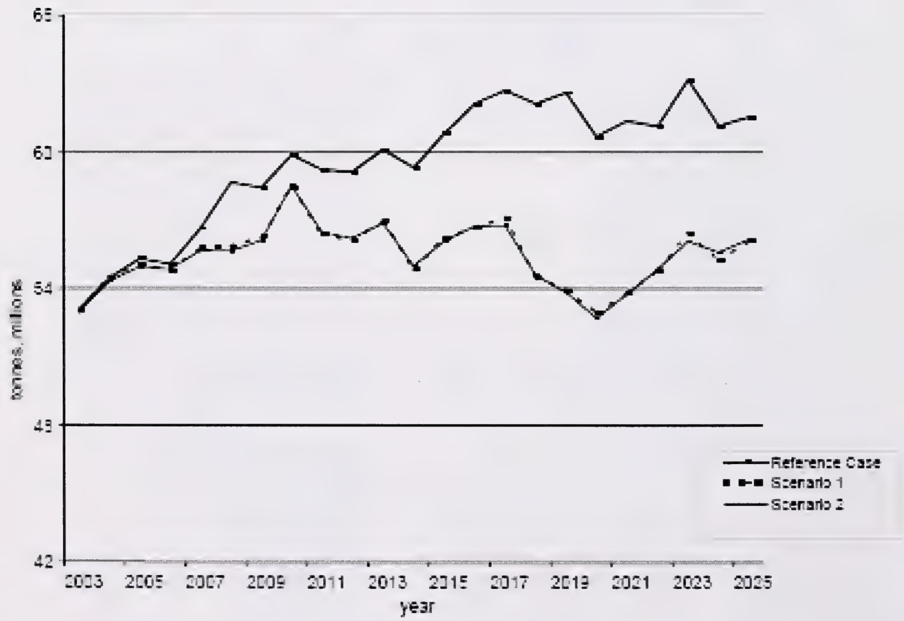


Figure 18. Modeled GHG Emissions Changes[10]



[10] CASA: An Emissions Management Framework for the Alberta Electricity Sector Report to Stakeholders, November 2003

The Electricity Project Team made 71 recommendations as part of a framework that would serve to manage air emissions from the electricity sector in Alberta. The predicted emissions of mercury and primary particulate matter were modeled based on the framework and the Reference Case, as shown in Figures #19 and 20. Implementation of the framework was predicted to reduce emissions compared to the Reference Case.

Figure 19. Modeled Primary Particulate Emissions[10]

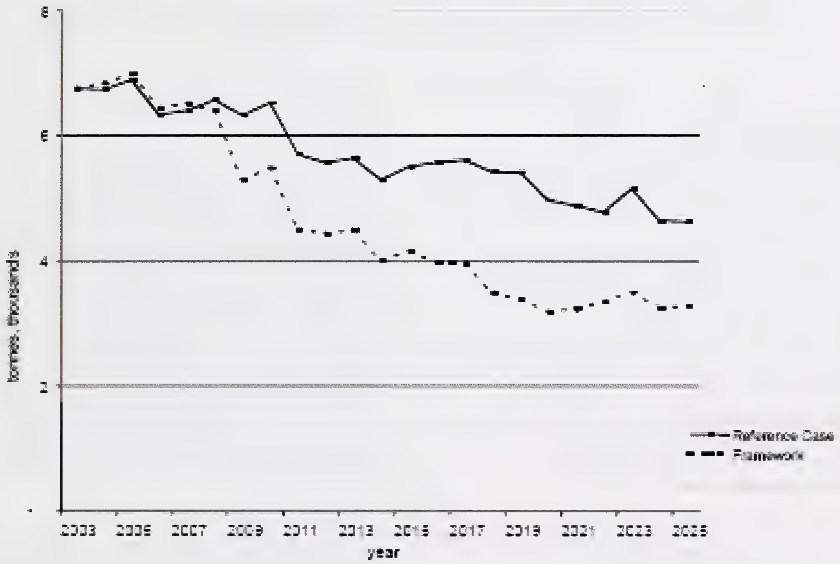
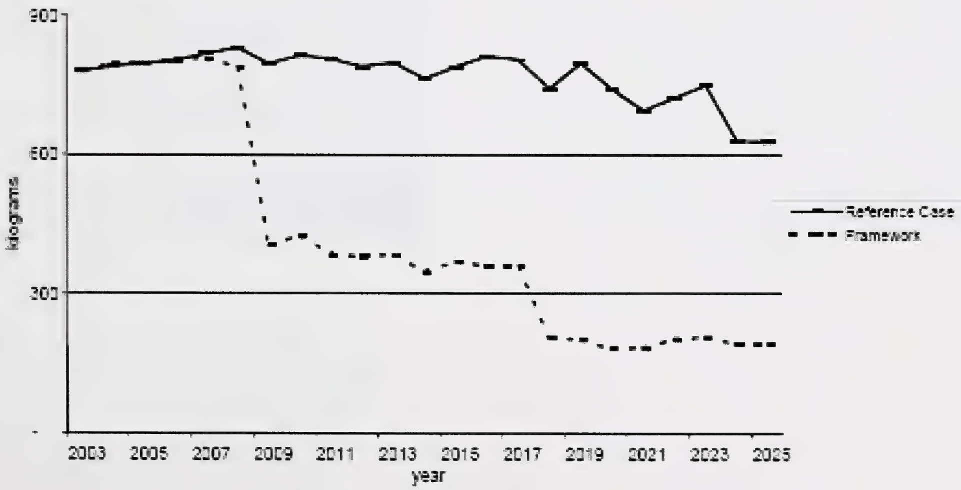


Figure 20. Modeled Mercury Emissions[10]



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[10] CASA: An Emissions Management Framework for the Alberta Electricity Sector Report to Stakeholders, November 2003

4.3 CASA Confined Feeding Operations (CFO) Project Team

Air emissions from CFOs in Alberta were investigated by the CASA Confined Feeding Operations Emissions Inventory Subgroup in 2007[11]. Plots of ammonia emissions from CFOs in southern Alberta were supplied by Environment Canada representatives. The plots were compiled using 2001 Statistics Canada data as well as local information to produce a 4x4km grid of emissions based on animal populations at a given CFO. Animal densities and emission factors were used to estimate emissions from different CFOs, as shown in Figures 21 to 24. The highest emissions are from cattle operations.

Figure 21. NH_3 Emissions from All Livestock[11]

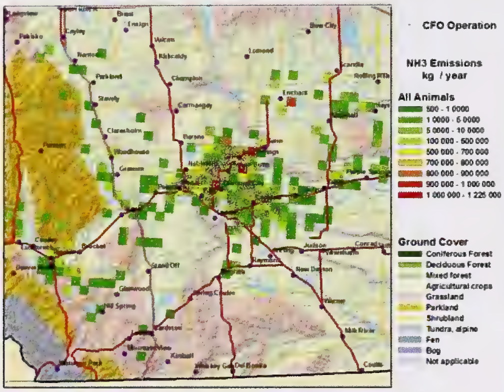


Figure 22. NH_3 Emissions from Cattle[11]

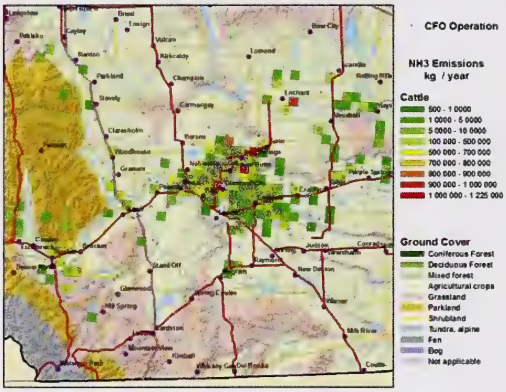


Figure 23. NH_3 Emissions from Swine[11]

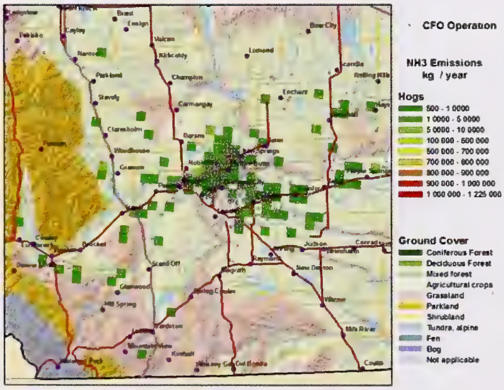
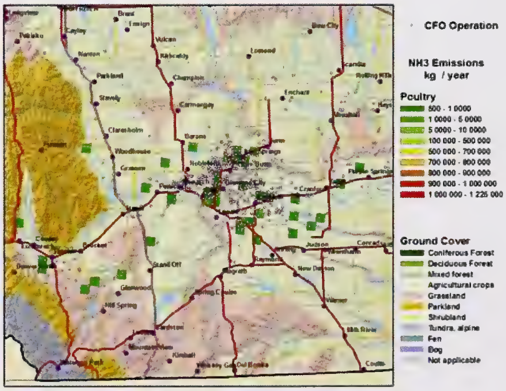


Figure 24. NH_3 Emissions from Poultry[11]



[11] CASA: Confined Feeding Operations Project Team Emissions Inventory Summary Report, June 2007 (pending release)

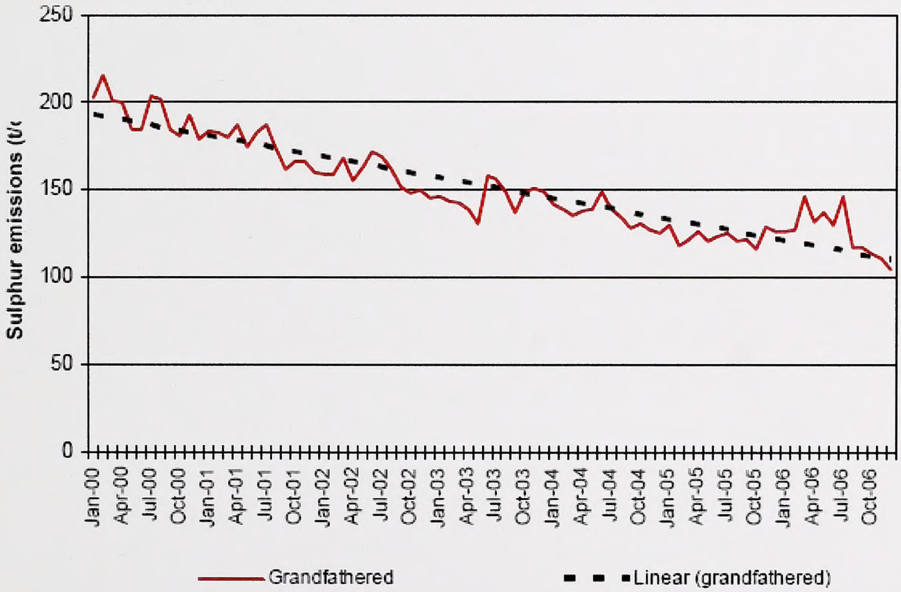
4.4 Sulphur Recovery – Alberta Energy and Utilities Board (EUB)

Through Interim Directive (ID) 2001-03[12], the EUB is publishing data on sulphur emissions from grandfathered sour gas plants (i.e. plants that do not meet the sulphur recovery requirements for new plants set out in ID 2001-03) and degrandfathered sour gas plants (i.e. plants that have been relicensed to meet the new plant requirements).

Between 2000 and 2006, 14 plants have made sulphur recovery improvements to the facility, 10 plants have been relicensed (degrandfathered) and 5 plants have shut down[13]. 31 grandfathered plants remained in December 2006 (18 sulphur recovery plants and 13 acid gas flaring plants).

Figure 25 shows how sulphur emissions have decreased by 35% between 2000 and 2006. This analysis includes grandfathered and plants that have been degrandfathered since ID 2001-03 was issued. The decrease in emissions is due to differences in throughput, lower sulphur inlets to plants and improvements in sulphur recovery.

Figure 25. Sulphur Emissions from Grandfathered and Degrandfathered Plants Sour Gas Plants[13]



[12] EUB: Interim Directive ID 2001-3: Sulphur Recovery Guidelines for the Province of Alberta, August 2001
[13] EUB: Sulphur Recovery and Sulphur Emissions at Alberta Sour Gas Plants, Annual Report, July 2007

5.0 Conclusions

Based on the information provided in this document it is clear that air emissions of various pollutants are both increasing and decreasing in Alberta. Strong economic activity and population growth has led to increases and projections of continual increases of some air emissions such as VOCs, ammonia, NOx, SOx , $PM_{2.5}$ and GHGs. Emissions of carbon monoxide are decreasing mainly due to technology improvements in the transportation sector.

Implemented recommendations from CASA project teams have led, or are predicted to lead, to decreases of certain air emissions. Policies resulting from the Flaring and Venting Project Team have been successful in reducing flaring and venting in Alberta. Current implementation of recommendations from the Electricity Project Team is predicted to reduce air emissions from the electricity sector.

Please note that this document was compiled using various sources of data on air emissions for Alberta. Each data source was prepared for a specific purpose and made specific assumptions. It is in that context that the information will have to be examined if an in depth analysis of air emissions data is required.